

STUDY ON THE AGE AND GROWTH OF BOGUE (*BOOPS BOOPS* (L.)) FROM THE CENTRAL ADRIATIC SEA

by

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ABSTRACT. - Growth of *Boops boops* (L.), Sparidae, from the central Adriatic was studied. Mean length-at-age values were estimated from otoliths and analysis of polymodal length frequency distributions. Growth pattern was well described by Von Bertalanffy growth equation. Growth parameters $L_{\infty} = 338.89$ mm, $K = 0.167$ and $t_0 = -1.296$ were calculated.

RÉSUMÉ. - La croissance de *Boops boops* (L.), Sparidae, de l'Adriatique moyen a été étudiée par otolithométrie et par des analyses de fréquences de longueur. Le rythme de croissance a été déterminé à l'aide de l'équation de Von Bertalanffy et les paramètres suivants ont été calculés : $L_{\infty} = 338.89$ mm, $K = 0.167$ et $t_0 = -1.296$.

Key-words : Sparidae, *Boops boops*, MED, Adriatic, Otolith reading, Growth.

Bogue, *Boops boops* (L.), Sparidae, is an important exploited species in the Adriatic. Its distribution was studied by Karlovac and Karlovac (1974) from the data of HVAR Expedition 1948/1949. These authors established that this species inhabited almost entire Adriatic being particularly abundant in the middle Adriatic along the edge of the Jabuka Pit. Aggregations of *Boops* are encountered at depths of 20 to 200 m in the open waters and the outer sides of islands. Trawl surveys carried out in 1963/1971 demonstrated the occurrence of this species around the Jabuka Pit (Jukic, 1975). Experimental catches from the channel area of the middle Adriatic in 1957/1958 showed their presence all year round with greater abundance in winter (Zupanovic, 1961).

Few studies on the biology of the bogue in the Mediterranean have been reported (Vidalis, 1951 ; Andreu and Rodríguez-Roda, 1951 ; Matta, 1958 ; Zúñiga, 1967 ; Girardin and Quignard, 1986). The present paper describes the population structure and patterns of the growth of bogue from open waters of the middle Adriatic, for a better understanding of the life cycle and population dynamics of this species.

MATERIAL AND METHODS

Most specimens for this study were collected from 1963 to 1967 during trawl surveys in the central Adriatic. A few samples were obtained in summer 1980. Whenever possible, biological data were recorded and some of samples were only measured. Fish total length expressed in millimetres was used in this paper. For comparison, a relationship between total and standard length was described by the following equation : $L_{st} = 0.837L_t - 0.781$.

A total of 252 pairs of *sagittae* otoliths from specimens of 135-235 mm total length were collected during June-July 1980.

Age was read from whole otolith immersed in either microscope immersion oil or a concentrated solution of sodium chloride, and viewed with a low power binocular microscope under reflected light and on a black background. Counts of zones used to determine age refer to the number of complete hyaline zones. The outer hyaline zone was termed complete only if opaque material was present on both sides.

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Age determination by examining whole otoliths proved fairly difficult, except for young fish. The main difficulty encountered was in distinguishing growth zones concerned the overall thickening of older otoliths, whose inner zones became less distinct. Therefore the age and accordingly length-at-age could be established with certainty in not more than 25 % of the specimens.

Methods of analysis of length frequency distribution for estimation of the mean length-at-age were used on length data classified in 5 mm intervals. The integral method for analysis of length frequency distribution recommended by Pauly (1982) was applied to data from 1963 to 1967. Bhattacharya's method modified by Pauly and Caddy (1985) was also used in the analysis of polymodal length frequencies, using only the June and July data of the period 1963-1967, and data collected in the same months in 1980.

Weight of 165 specimens ranging from 130-235 mm total length was used for determination of the relationship between weight and length by the classical allometric equation: $W = aL^b$, where W = fish weight in grams and L = total length in millimetres.

RESULTS

Length-at-age determination

The Adriatic bogue spawn in spring, mainly during May (Alegría Hernández, unpublished data). Therefore it might be considered that hatching occurs during May and June. Judging from this, only specimens sampled in June-July were utilized for this study.

The results of age determination by otoliths are given in Table I. Specimens the otoliths of which showed clear complete hyaline zones, mainly belonged to the 2-5 age groups. Only the otoliths of a specimen of 128 mm presented one complete hyaline zone. 0-age group was not recorded from the samples.

Annual data for the period 1963/1967 and 1980 on the fish length were sufficient and within a large range (115-250 mm), for the application of the methods of frequency distribution analysis. Modes representing age groups were apparent (Fig. 1). The extreme lengths were little represented in the samples, probably because of different temporal and spatial distribution of these groups.

The integral method of analysis of length class frequencies was applied on the data from the period 1963/1967 distributed by years. In this way it was possible to distinguish four age groups. The application of the method proposed by Pauly and Caddy (1985) on the data from June and July 1963/1967, allowed the identification of the same

Table I : Estimates of mean length-at-age (mm) of *Boops boops* from the central Adriatic. Parentheses indicate the number of individuals.

Age group	Otolith reading	Pauly (1982) integral method	Pauly and Caddy (1985) method	
			1961/67	1980
2	147.26 (17)	142.50	143.21	141.02
3	175.32 (20)	173.00	174.03	170.08
4	200.48 (18)	200.00	198.63	193.60
5	220.25 (8)	221.50	220.75	215.13
6	238.00 (4)	-	-	232.25

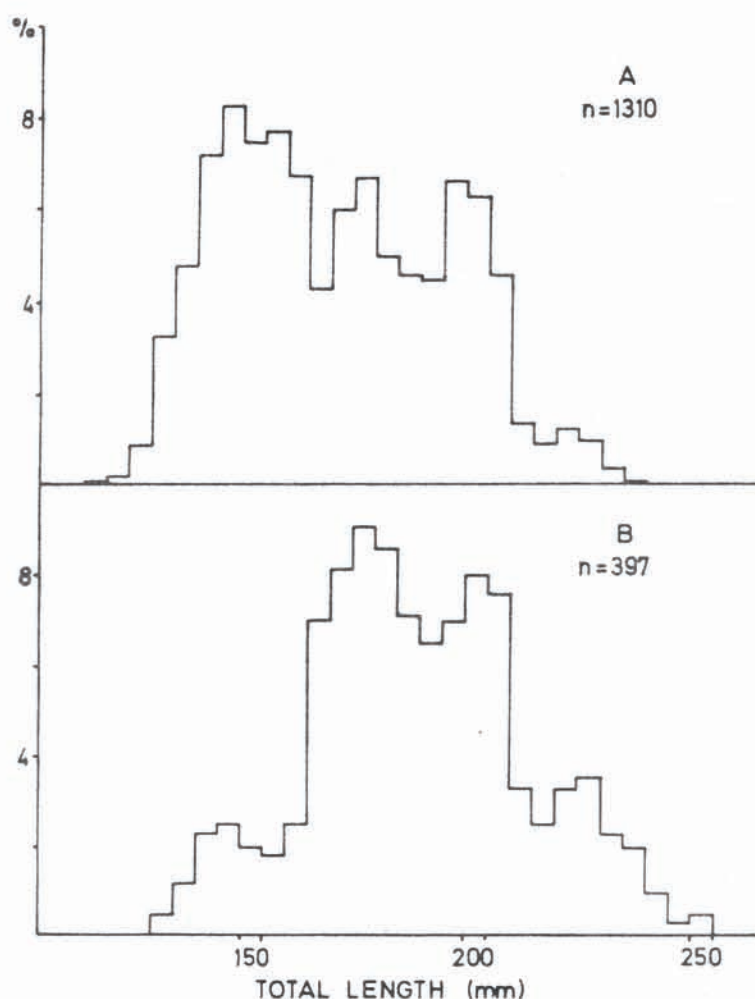


Fig. 1 : Length frequency distribution of the bogue from the central Adriatic in 1963/1967 (A) and 1980 (B).

groups with very similar mean length values (Fig. 2A). Five age groups were separated from the June-July 1980 data (Fig. 2B). Mean length-at-age values estimated by all these methods are presented in Table I together with values determined from otoliths.

Growth in length

Several methods may be applied for solution of the Von Bertalanffy equation. Two regression equations were used to calculate L_{∞} , K and t_0 ; the first one is the MG functional regression of the classical Ford-Walford's method (Ricker, 1975), by which four sets of L_{∞} and K values were obtained (Table II). Corresponding values t_0 were calculated separately by the method proposed by Gulland (1964).

The second method is the Beverton approach based on the regression between $\ln(L_{\infty} - L_t)$ and age. This method requires some independently defined values of the asymptotic length obtained by Ford-Walford method were used with the corresponding

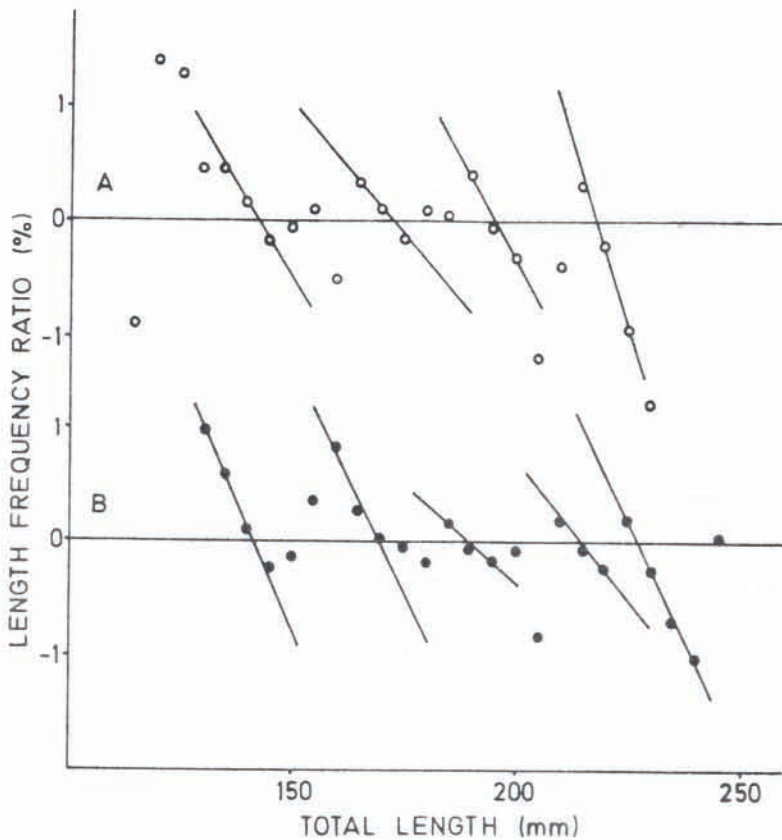


Fig. 2 : Length-at-age of the Adriatic bogue determined by length frequency analysis from 1963/1967 data (A) and 1980 data (B) by Pauly and Caddy (1985) method.

length-at-age determined from otoliths and analysis of length frequency distribution. Results are given in Table III.

As shown by the sum of squares of deviations of theoretical values from the observed length, the smallest departure was recorded for values estimated by both Ford-Walford and Beverton approaches, on the basis of length-at-age determined by analysis of length frequency distribution from the 1963/1967 data (Pauly and Caddy's method, 1985). Thus these values point to a better fitting of growth of growth parameters.

Therefore, the theoretical growth in length of *Boops boops* in the Adriatic Sea is better expressed by the following equation:

$$L_t = 338.89 [1 - e^{-0.167(t+1.296)}]$$

The lifespan 16.6 years was estimated after Taylor's concept (Taylor, 1962) and refers to the age of fish when they attain 95 % of their total length.

Table II : Growth parameters of *Boops boops* from the central Adriatic estimated using Ford-Walford method, length-at-age determined by : 1 - otoliths ; 2 - Pauly (1982) integral method from 1963/67 length frequency distribution ; 3 - Pauly and Caddy (1985) method from 1963/67 length frequency distribution ; 4 - Pauly and Caddy (1985) method from 1980 length frequency distribution ; d - departure of theoretical values from observed values.

Parameters	1	2	3	4
L_{∞} (mm)	332.17	343.69	338.89	339.18
K	0.167	0.169	0.168	0.156
t_0	-1.514	-1.169	-1.290	-1.456
$\sum d^2$	0.767	0.996	0.481	0.735

Table III : Growth parameters of *Boops boops* from the central Adriatic estimated by Beverton method (Ricker, 1975). Length-at-age determined as indicated in Table II ; d - departures of theoretical values from the observed values.

Parameters	1	2	3	4
L_{∞} (mm)	332.17	343.69	338.89	339.18
K	0.168	0.167	0.167	0.155
t_0	-1.481	-1.208	-1.296	-1.460
$\sum d^2$	0.626	0.513	0.409	1.023

Length-weight relationship

The relationship between weight and length was calculated separately for sexes and for all specimens together by GM functional regression. The values obtained refer to sexually mature individuals of 2 to 5 years age, caught during summer, that is during the resting stage in sexual cycle. The following equations were found :

Males : $W = 2.637 \times 10^{-5} L^{3.231}$ ($n = 68$, range 128-223 mm, $r = 0.984$, slope standard error = 0.092, $s^2_{y,x} = 0.0008$).

Females : $W = 5.635 \times 10^{-5} L^{3.088}$ ($n = 97$, range 135-230 mm, $r = 0.991$, slope standard error = 0.063, $s^2_{y,x} = 0.0006$).

Total : $W = 6.440 \times 10^{-5} L^{3.113}$ ($n = 165$, range 128-230 mm, $r = 0.990$, slope standard error = 0.078, $s^2_{y,x} = 0.0005$).

The results show positive allometric growth in both sexes. Nevertheless, the length increment in males was less than the gain in weight ($b = 3.231$) and the value for b (3.008) for females shows that growth in weight relative to length was almost isometric. F-test for difference between regression coefficients and analysis of variance revealed no significant difference between allometric growth rate in males and females.

DISCUSSION AND CONCLUSIONS

The number of age groups that could be determined by otolith aging for *Boops boops* from the Adriatic Sea is very similar to that obtained by the analyses of length frequency distribution of samples from different periods. However, certain variability was observed when determining mean length for individual age groups. Comparing the length-at-age values for the Adriatic bogue obtained by different methods, the mean length determined from otoliths for the second year appeared to be overestimated while the mean length for the sixth, and possibly that for the fifth years, appeared to be underestimated. This often happens because the size classes at the extremes of the size distribution in samples are usually poorly represented.

Some other authors determined similar number of age groups for this species from other areas is the Mediterranean (Navarro and Navaz, 1946; Andreu and Rodríguez-Roda, 1951; Matta, 1958; Zúñiga, 1967; Romestand, 1978; Girardin and Quignard, 1986). These authors used a variety of methods in age and length-at-age determinations. However, the results are not easily comparable since the length data were expressed as total, standard or fork length. In spite of these difficulties, some comparisons were made later by appropriate conversion equations.

Results of age determination obtained by otolith reading are very similar to those reported by Romestand (1978, after Girardin and Quignard, 1986) for bogue from the Gulf of Lion. Meanwhile, the number of Adriatic bogue, the age of which was determined with certainty, was small and obtained mean length values could not be used for the calculation of growth parameters without significant error.

Irrespective of the limitations of methods based on the analysis of polymodal length frequency distribution, still the age-length obtained in this way was close to that given by Andreu and Rodríguez-Roda, (1951) and Zúñiga (1967) for bogue from the Mediterranean coast of Spain, and that for bogue from Gulf of Lion (Romestand, 1978, after Girardin and Quignard, 1986). The values obtained from data for 1963/1967 showed best agreement with results reported by these authors. Mouneimne (1978, after Girardin and Quignard, 1986), established higher values for 2 and 3 year old bogue from the area of Lebanon. The paper by Girardin and Quignard (1986) supplied a rather detailed information on the growth of bogue from the western Mediterranean (Gulf of Lion). The authors applied a scalimetric method for age determination in relation to the fish fork length. After an adequate conversion it was possible to compare their results with these of this paper. The values of mean length at individual age they reported are slightly higher than those for the Adriatic bogue. This difference is more evident for fourth and fifth years of age.

Several Von Bertalanffy growth curves were fitted to describe the age-length relationship. The smallest difference between observed and theoretical lengths for individual ages were recorded in values obtained from data for the 1963/1967 period, calculated by the analysis of length frequency distribution after Pauly and Caddy's (1985) and fitted Beverton's method. The growth parameters $L_{\infty} = 338.89$ mm, $K = 0.167$ and $t_0 = -1.296$ reflected better the changes in the Adriatic bogue growth. Low value of growth rate points to a slow growth of this species. The lifespan, estimated to be 16.6 years, is also indicative of their slow growth.

Asymptotic length of 338.89 mm was considerably greater than maximum observed length of 250 mm. This value, however, agrees better with the maximum length of 350 mm reported by Soljan (1948) and Grubisic (1982) for the bogue of the Adriatic Sea. Girardin and Quignard (1986) found a specimen of 335 mm total length in the Gulf of Lion. Quignard (1973)

in FAO species identification sheets assigned a maximum length of 36 cm to bogue from the Mediterranean Sea.

Even though there is, in general, an agreement in the number of determined age groups and in length-at-age values between the population sampled in 1963/1967 and that from 1980, a difference in growth rate was observed. This was probably caused by the smallest length-at-age calculated for the latter one. Lower growth rate of bogue sampled in 1980 points to slower growth pattern but at the same time it suggests a lower natural mortality during this period. That may be accounted for by the difference in the condition of the fish between the sampling periods.

In spite of the different methods used, especially for ageing, it is possible to achieve certain agreement of the growth pattern of bogue from the French Mediterranean coast (Girardin and Quignard, 1986) obtained by scale reading and the growth pattern of Adriatic bogue determined by other methods. This was particularly noted in growth parameters that these authors estimated for bogue showing between 1 and 11 scale annuli: $L_{\infty} = 29.6$ cm fork length (after conversion 33.77 cm total length) and $K = 0.194$. Growth parameters of bogue from the Castellon coast $L_{\infty} = 352$ mm total length, $K = 0.171$ and $t_0 = -2.064$ determined for fish between 1 and 5 years of age (Zúñiga, 1967) are indicative of presence of a bogue population which has a faster rate of growth in that area. To conclude, growth pattern of bogue from the Adriatic waters appears to be very similar to that of the bogue population inhabiting the western Mediterranean coast.

The length-weight data for the Adriatic bogue show allometric growth for both males and females, but it was nearly isometric for females. No significant difference between the allometric growth rate (3.113) and the values 3 was found. But it is necessary to mention that the sample size used was too small and the variation of individual weight too great to consider the obtained values as parameter values.

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